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ARTICLE

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ABSTRACT
Agricultural systems result of the coevolution between social and natural systems, where biodiversity and natural resources play an important role, emerging interactions between crops and the natural environment that allow the development of ecological processes which interact with external inputs. This research aims to describe the agricultural practices developed by the Guaraní Indigenous people in the agricultural systems located within the biodiversity corridor of the Upper Parana Atlantic Forest. This exploratory study is focused on multiple cases, with a qualitative approach and from data collected during 2017 and 2018 in eleven indigenous communities. The main practices developed for the management of biodiversity are polyculture, rotation, and embroideries; they also practice agroforestry and livestock-raising. The main difficulty they face is the reduction of the surrounding biodiversity, which affects the sustainability of the system. This study shows ways for nature-based solutions and ecosystem-based adaptation according to current needs for greening the economy.

1. Introduction

Through the processes of simplification of agricultural systems to improve their management, a high uniformity is promoted, altering biodiversity both at the scale of the landscape and the farm in systems in which some resources still depend on external factors such as pollination, water and biological controls. Peasant and indigenous agricultural systems are the result of cultural and biological co-evolution over time and through learning and, despite the diversity of existing systems, these have some points in common such as high levels of biodiversity, conservation and management of soil and water resources, productive diversity, resilience, traditional knowledge, and forms of collective organization. Agrobiodiversity is a key element in these agroecosystems, and patterns of diversity, use and management are distinguished in relation to geographical-cultural regions of location of agroecosystems and plots.

The Convention on Biological Diversity defines biodiversity as “the variability between living organisms of all types or origins including, but not limited to, terrestrial, marine and other aquatic ecosystems and...
the ecological complexes of which they are part of [2]. Biodiversity is the set of living organisms and resources, their genetic variability and how they are integrated into the landscape through ecosystems. The Alto Parana Atlantic Forest is one of the most endangered ecoregions shared among Argentina, Brazil and Paraguay; in Paraguay, around 10% remains with a representative forest cover. Original forest remnants gave the opportunity to design and create a Biodiversity Corridor within the general view for the conservation of the trinational Corridor which years ago pioneered a biological vision coupled recently by Chaco Biological Corridor [3]. This trinational corridor with Argentina and Brazil is expressed in Paraguay by the Alto Parana Biodiversity Corridor (APBC) [6] and its historical landuse changes have been gathered in WWF/FVSA report [7]. This national corridor recognized legally as the first corridor in Paraguay is composed of nuclear or core zones (protected area) with a productive landscape surrounding these ones which visually are patches of forests in the landscape. To maintain the connectivity among the remaining patches it is important to work with the agricultural practices and if areas are to be reconnected given the lost connectivity, these is to be done with local producers. The southernmost limit of this Corridor has been highlighted in terms of governance [8].

Agrobiodiversity arises from traditional knowledge as a result of a co-evolution between the natural environment and humans, where small changes are introduced (considering the relationships of social ecosystems and the natural ecosystem) so that the environment adapts to the needs of human beings. At the same time, humans have adapted the productive system to the prevailing environmental conditions [9].

The Guaraní People is a linguistic family of Amazonian origin, who have occupied Paraguay about 1,000 years ago, characterized by the combination of agriculture with hunting and fishing, the gathering practiced in the forest; traditionally 80% of the diet depended on crops such as corn (Zea mays L.), bean (Phaseolus vulgaris L.), manioc Manihot esculenta Crantz, sweet potato (Ipomoea batatas L.) Lam. and Cucurbita pepo (Duchesne) Poiret [10,11].

For the Guaraní, the importance of agriculture does not depend only on the quantity or quality of production, but also on what its own productive means. Its practice involves internal organization, reciprocity, exchange of species, experiments, rituals, renewal of life cycles, among others [12].

Ecosystem based adaptation (EbA) and Nature-based solutions (NbS) have been indicated as ways of greening our planet and help adapt to climate-changes [13] and in many countries such as Paraguay, indigenous people have been living in different kinds of ecosystems such as high humid forest as the case of the Guaraní people in Eastern Paraguay. The practices they may have evolved with may show pathways for these solutions. Exploring information on traditional knowledge and productive practices in native people may help identify ways of greening the economy, finding NbS and adapt according to the ecosystem (EbA) where these practices are held.

Today, according to data from the III National Indigenous Census conducted in 2012 [14], 61,902 people identify themselves as members of one of the five peoples of this language family in Paraguay. Within the APBC, there are three of these indigenous peoples, the Aché, the Mbya and the Ava Guarani [10].

This Biological Corridor is a space defined under a protected area management category of the National System of Protected Areas of Paraguay (SINASIP), of just over one million hectares and located on the right bank of the Paraná River associated with the Itaipú Hydroelectric Dam discussed in the 2018 Forum of Green Business (https://paraguaybiogreenforum.com/corredor/).

The objective of this research was to describe the main agricultural practices developed to increase biodiversity by indigenous family farming in the biodiversity corridor of the Alto Paraná Atlantic Forest through the identification of the functional biodiversity used and production techniques to promote this biodiversity.

2. Methodology

The research was designed as an exploratory type to understand the relationship of the productive systems and nature, with multiple case studies with a qualitative approach. The variables studied correspond to the dimensions of biodiversity based on the proposal of Gliessman’s [13] (Table 1) and the main agricultural practices that enhance these dimensions.

<table>
<thead>
<tr>
<th>Table 1. Biodiversity dimensions after Gliessman [2]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension</strong></td>
</tr>
<tr>
<td>Genetics</td>
</tr>
<tr>
<td>Specific</td>
</tr>
<tr>
<td>Vertical</td>
</tr>
<tr>
<td>Horizontal</td>
</tr>
<tr>
<td>Structural</td>
</tr>
<tr>
<td>Temporal</td>
</tr>
<tr>
<td>Functional</td>
</tr>
</tbody>
</table>

DOI: https://doi.org/10.30564/re.v3i3.3358
The study population includes indigenous communities that are currently within the Biological Corridor identified by the Paraguay Biodiversity Project (https://projects.bancomundial.org/es/projects-operations/project-detail/P094335). Areas where indigenous communities are present and these communities reside in critical areas for the connectivity within the Corridor, either to maintain it or enhance the connectivity or areas of importance for the forest restoration. With these criteria, 20 priority areas were identified.

These areas comprise 11 indigenous communities (Table 2) in which random sampling was carried out according to the weighting of the population benefited by the project and the interview with key informants. Data were collected through interviews and surveys conducted with families and key informants living in the communities during 2018 and 2019. The project received the prior informed consent by the people participating and followed the Paraguayan Law in terms of consent and consult with indigenous people.

Table 2. A total of 46 family units (608 individuals) were visited and interviewed within 11 indigenous communities.

<table>
<thead>
<tr>
<th>No</th>
<th>Community</th>
<th>People/Nation</th>
<th>Population</th>
<th>Percentage</th>
<th>Sampling units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tapysavy</td>
<td>Mbya Guarani</td>
<td>44</td>
<td>7%</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Ypeti</td>
<td>Mbya Guarani</td>
<td>42</td>
<td>7%</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Mical Lopez</td>
<td>Ava Guarani</td>
<td>60</td>
<td>10%</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Yvyty Miri</td>
<td>Mbya Guarani</td>
<td>25</td>
<td>4%</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Itanarami</td>
<td>Ava Guarani</td>
<td>78</td>
<td>13%</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Montania I y II</td>
<td>Ava Guarani</td>
<td>53</td>
<td>9%</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Ara Pyahu</td>
<td>Ava Guarani</td>
<td>26</td>
<td>4%</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Arroyo Mokoi</td>
<td>Ava Guarani</td>
<td>65</td>
<td>11%</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Cerrito</td>
<td>Mbya Guarani</td>
<td>45</td>
<td>7%</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>Mytuy Araguayu</td>
<td>Ava Guarani</td>
<td>12</td>
<td>2%</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Acaray mi centro</td>
<td>Ava Guarani</td>
<td>158</td>
<td>26%</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>608</td>
<td></td>
<td>46</td>
</tr>
</tbody>
</table>

3. Results and Discussion

The 11 indigenous communities studied have communal ownership of the land, but the production systems and animals raised are family-owned; the leader of the community is the one who assigns the space or place where the family can settle their crops, which normally constitute small spaces of no more than 0.5 ha distributed in the forest; each family owns three to five of these spaces (1.6 – 7.5 ha); coinciding with what Glauser [10] said that the Paĩ Tavyterã (another of the peoples belonging to the Guarani language family that inhabits Paraguay) have on average about 2.5 ha of crops per family.

For them, the agroecosystem encompasses, in addition to the crops themselves, the surrounding space, fallow areas and the forest; therefore, the community as a whole could be considered as an agroecosystem. Productive systems or agroecosystems are in constant interaction with the forest as has been shown by Glauser [10], Ladeira [12] and Lehner [11]. This phenomenon occurs mainly in those communities that still have significant forest remnants, which constitute 8 of the 11 communities studied; in the other 3, the productive systems have almost no interaction with the environment.

The distribution of land use in the 11 communities studied (Figure 1) shows a potential relationship between the area of temporary crops and the availability of forest, coinciding with what Glauser [10] pointed out that as the forested area decreases, the areas destined for the production of other types of food increase in order to compensate for the decrease in harvesting within the native forests.

Guarani agriculture is a migratory or slash, tomb and burn agriculture; based on a lunar and seasonal calendar governed by a large number of religious rites; characteristic that can still be observed in the 11 indigenous communities. The crop cycle begins with the selection of a new site in the forest (currently three of the communities studied no longer practice this cycle, keeping their crops in the same places, due to the lack of forests), proceeded for a time of cultivation and a period of rest for the soil.

Within the agricultural systems, permanent and temporary crops are observed; among the main permanent crops, there is a great variety of fruit crops among which banana stands out for its frequency (Musa X paradisiaca L.), the yerba mate (Ilēx paraguariensis A.St-Hil.), the orange tree (Citrus sinensis (L.) Osbeck) and the papaya (Carica papaya L.); according to interviews, these crops are an important source of food, mainly for children, and partly replace the fruits of the forest; on the other hand, yerba mate today has become an important source of income through the sale of its leaves.

Temporary crops are represented by corn, bean and cassava, complemented by crops of sweet potatoes, two varieties of pumpkins (Cucurbita mixta Duchesne), in addition to other recently introduced species such as sesame (Sesamum indicum L.) or rainfed rice (Oryza sativa L.).

As for the specific diversity of agricultural crops sown, each family on average sows between 7 to 15 species, among annual crops, fruit trees and vegetables. Among
communities, 7 have a number of between 14 and 15, and four are below the 9 species sown. Though the number of species has decreased with respect to the traditional agriculture of the Guarani, based on the comments collected, there is still interaction between these crops and the natural environment which may suggest the importance of the associated biodiversity for them. This situation coincides with that expressed by Glauser [10] who found a diversity of cultivated species of between five to 11 species among the Pai Tavyterã communities.

In conjunction with this variety of species, there is also a genetic variety in terms of cultivated items, with 20 varieties of corn, 12 varieties of sweet potatoes, 7 of beans as well as the bean (*Vigna unguiculata* (L.) Walp.) and sugar cane (*Saccharum officinarum* L.) and 5 varieties of cassava.

The agricultural practices developed by the Guarani to enhance agricultural biodiversity within their systems are grouped into four main practices and are in line with what Gliessman [15] reported: cover crops, polycultures, rotations and embroidery.

In Paraguay, traditional Guarani agriculture did not possess exclusive plant species for the cover and used different species and varieties of beans and peanuts, combined with pumpkins [16]. Eleven communities visited cultivated beans and pumpkins; while in four sweet potatoes were grown, and in two, bean is cultivated in association with watermelon (*Citrullus lanatus* (Thunb.) Thell.) and melon (*Cucumis melo* L.).

Guarani agriculture has a very specific rotation system that consists of the alternation of crop cycles with soil rest cycles (fallow or *kokuere* as it stands in guarani language).

**Figure 1.** Distribution of land use in the indigenous communities studied

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This complete cycle (Figure 2) could last approximately 30 years, where 5 corresponded to crops and 25 to soil recovery through the ecological process known as natural succession; the right time to let a soil rest is identified by the presence of natural indicators such as the yyy'a (Jacaratia corumbensis Kuntze), the kapi'i ati (Cenchrus echinatus L.), the kapi'i una (Bidens pilosa L), kapi'i pororó (Digitaria insularis L.), the ūuāi pytā (Solanum sisymbrifolium Lam.) and the kaugueti (unidentified species). This rotation system is still partially applied in 8 of the communities, where the habilitation of new places (slash-and-burn) is subject to approval by the community assembly; on the other hand, in 3 communities it is no longer practiced because they almost no longer have forest cover.

For the effective practice of this traditional cycle, biodiversity is considered of vital importance, since the recovery of the soil depends on it; in traditional management, once the soil shows signs of exhaustion, they leave it at rest and the succession process becomes evident. The appearance of these indicator species needs to be furthered researched.

For polyculture or crop association, maize is usually combined with cassava and peanuts; corn with cassava and beans; corn with cassava and beans and cassava with watermelon; in addition, different kinds of pumpkins are planted by dispersing seeds on the ground. These combinations are observed in all indigenous communities, mainly the planting of cassava and corn, associated with beans pumpkins. These crop combinations combine with those found by Glauser [10] which mentions that the Paũ Tavyterã usually grow corn with pumpkin; corn with cassava and bean; cassava, bean and sweet potatoes in an associated way; among other combinations.

Embroidery techniques were one of the key traditional Guarani agriculture practices, since agroecosystems were completely surrounded by forest and fallow areas [10,16].

Currently, in the study area, this can only be seen in those communities that still have forest cover (8 communities); in the others they have incorporated as embroideries the crops of species such as sugar cane (2 communities) or pastures such as Cameroon Grass (Pennisetum purpureum) (1 community). In addition, they maintain natural regeneration spaces in depleted plots, called kokuere or fallow land.

This interaction of cultivated spaces with natural spaces could demonstrate the importance of the associated biodiversity, since, according to the interviews conducted, through this, pest control was achieved, reducing the effects of droughts, winds and frosts, improving the sustainability of the system. It is important to note that pollination is also a service of the surrounding nature, not always visualized.

In addition to the existing techniques mentioned, there are others that also have an impact on the biodiversity of the system, such as agroforestry systems, and the integration of crops and animals [3].

In traditional Guarani agriculture it is normal to

![Figure 2. Crop cycle in the Guarani communities studied](https://doi.org/10.30564/re.v3i3.3358)
observe the existence of trees in crop spaces, as this helps a faster recovery of forest cover, once the soil begins to experience symptoms of exhaustion, with which natural cycles could be accelerated. Currently, they have also incorporated the cultivation of different species of fruit trees such as the citrus and the papaya, in addition to the yerba mate (*Ilex paraguariensis* A.St-Hil.) coinciding with what was observed with Glauser [109] who mentions that the Paï Tavyterã cultivate different species of fruit trees around houses for human and animal consumption.

Currently, in all communities raising of minor animals, and in 6 cases, cattle is integrated into the farming systems. Smaller animals normally have a lot of freedom of movement and interact with crops naturally; on the other hand, cattle are usually fenced in natural or cultivated pastures. These domestic animals play an important role in maintaining the diversity of plants by helping with seed dispersal.

4. Conclusions

Biodiversity continues to play a preponderant role in Guarani agriculture and its management occurs both according to the number of species cultivated and the structure, both cultivated and associated with the interior of the farm and in the surrounding landscape. The native areas of forests are needed for the restoration of lands used for crops. These practices may be seen as solutions for sustainability for restoration of habitats, and could be considered as Nature-based Solutions (NBS) which increasingly are being debated to guide the design of resilient landscapes [17] including sustainability, resilience, ecosystem services, coupled with human and environmental needs. Ecosystem-based adaptation is considered needed to fight against climate change and advance with adaptation [18], this study shows a way of productive systems associated with a particular ecosystem, the Atlantic Forest where native people have evolved practices in association with these ecosystems, and though human induced, these agrosystems increase resilience to climate change.

The associated biodiversity is fundamental for the sustainability of agriculture considering that it depends on the existence of different ecological processes that provide fundamental ecosystem services such as nutrient recycling, pest control, resilience capacity, and ecosystem services provided by forest also benefit food security to the Indigenous People.

Currently, the main difficulties faced by Guarani communities are linked to the extreme reduction of surrounding nature which generates some imbalances in the system and causes them to incorporate inputs and practices outside their culture, mainly related to the control of pests and fertilizers. The conservation and restoration of biological corridors such as the Alto Parana Biological Corridor in Paraguay and its connection with natural habitat in the neighboring countries rely on nuclear areas and sustainable practices which are associated with the native biodiversity, native people such as the Guaraní shows a way of doing this locally and help the connectivity of the entire biological corridor.

References


ARTICLE
Discussion on the Construction of Ecological Water Network in Guangxi Province of China

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ABSTRACT

The water network plays an important role in maintaining the stability of regional water resource and ecological environment. It is also affecting the harmonious development between environment and economy. Guangxi is one of the provinces with relatively rich water resources in China, while the ecological water network exists deficiencies and faces challenges. The current situation and defects of ecological water network in Guangxi province will be discussed. By studying the experience of the establishing and the preserve of ecological water network in various regions at home and abroad, some suggestions and targeted measures will be mentioned for a better ecological water network in Guangxi.

1. Introduction

In order to pursue the rapid increase of economy and a higher working efficiency, many ecological and environmental problems were ignored in the past\textsuperscript{[1]}, especially ecological water problem. Water pollution, soil erosion and deterioration of ecological environment in some areas have become increasingly prominent. In Chinese main river basins (Yellow River, Songhua River, Huai River and so on), scientists found that the ammonia nitrogen, COD (chemical oxygen demand) and other measured index were above standard value. The same situation happened in the Three Gorges Reservoir area, the amount of heavy metals and pollutant exceeding the normal standard. The influence of soil erosion in China is in a wide range. The Loess Plateau is the most serious area that suffered from soil erosion, according to the observation, the Yellow River sediment transport is about 1.6 billion tons per year, 90% of which comes from the Loess Plateau. In order to address ecological water problem systematically and enhance the water security ability comprehensively. It is necessary to improve the regional water environment, strengthen the water ecological restoration ability and developing water landscape. Not only the rapid economic growth, but also the ecological water networks should be considered. Constructing ecological water network system have become one of the significant contents of water conservancy development in the fourteenth five-year plan.

2. The Development Status Domestic and Abroad

2.1 The Water Network Development

In the 21\textsuperscript{st} century, Shandong province is one of the
earliest provinces to conduct the construction of modern water network in China. Liu Yongyi and Wang Weiping [3] studied the operation law of modern water network through the provincial, municipal and county network architecture water network system. The management of modern water network should be unified by various level water administration, and administrative departments maintain communication to establish a regional water network. With the proposing of digital river basin research and the successfully demonstrating of digital river basin application systems such as Digital Yellow River [4] and Digital Qingjiang River [5], the research of digital water network has been gradually carried forward. In addition, the relevant information of water network was extracted digitally [6] by 3S, visual simulation, communication engineering, unmanned aerial vehicle (UAV) and other advanced technologies to construct the digital water network system. In 2004, the concept of “intelligent water network” was put forward firstly in Australia [7]. The network offers an internet platform to different regional departments. Based on geographic information, departments can exchange latest hydraulic information, then the related data were processed and integrated for a better use. In addition, the intelligent water network can exhibit technological process, for example, seawater desalination. In 2013, China national intelligent water network [8] project framework was formed preliminarily, leading to the digital water network has been further upgraded to the level of digital water network and intelligent water network. Intelligent water network [9] is such an integrated management and control platform that comprises water physics, water information and water management through intelligent means and technologies. And water network construction has entered a more intelligent era since then.

2.2 The Water Ecological Development

The ecological oriented optimal allocation of water resources [10] has always been a hot topic discussed by experts domestic and abroad. In 2020, Li et al have showed, the ecological water network can guarantee the water area, ecological corridor and ecological diversity better than the independent river system, once the original natural habitat and ecological process of the ecological water network are destroyed, it will not only threaten the regional ecological security, but also gradually lose the regional landscape features [11]. If fish migration areas or foraging areas have been damaged, the survival of fish stocks will be threatened. Britain [12] has developed a relatively perfect legal system for this aspect. As early as in The Water Resources Act of 1963, there was a regulation on “minimum acceptable flow”. As early as 2005, in China, Hubei province [13] issued a variety of laws and regulations on water environment and water ecological protection in order to vigorously promote the construction of water ecosystem. However, the construction of water ecological network has been advancing quite slowly [14].

3. Current Situation and Existing Problems of Water Network Construction in Guangxi Province

3.1 Current Situation of Water Ecological Resources

Guangxi is one of the provinces with rich water resources in China [15], with developed water system and numerous rivers. The whole region [16] belongs to four river basin of Pearl River Basin, Yangtze River Basin, coastal basin and Red River Basin, accounting for 85.4%, 3.5%, 10.3% and 0.8% respectively. There are 1350 rivers with water-collecting area [17] of 50 km² and above, with a total length of 52386 km. There are more than 4550 reservoir projects and more than 40000 dams in the region. Meanwhile, Guangxi is also one of the three provinces with the richest biodiversity in China [18]. There are 8562 species of wild plants ranking the third in China and 1149 species of terrestrial vertebrate wildlife, ranking second in China, while fish account for nearly a quarter of the total freshwater fish species in China. The area of contiguous wetlands is 754300 hectares, and forest [19] covers an area of 14.8 million hectares, with a forest coverage rate of 62.37% ranking third in China. 78 nature reserves have been built [20], occupying 5.3% of the total land area of the region. Consequently, there are 90% of the national key protected wild animal and 82% of the national key protected botanic species in Guangxi, as well as 31% of mangrove wetlands.

3.2 Main Problems

1. Insufficient connection water system of rivers, lakes and reservoirs

The first problem is that the serious shrinkage of the flow capacity of rivers and insufficient connectivity. In Guangxi, due to the long-term lack of maintenance and fix, some of the water conservancy infrastructures such as rivers, lakes are damaged and broken. Besides, some villagers exploit and utilize water resources unreasonably and other fill clay into the river illegally for expanding land, which contribute to flow rate reduced and river siltation. At the same time, the self-purification ability of water ecology is reduced lading to the siltation of some rivers with a trend of aggravation [21]. These phenomena
not only reduce the ability to resist flood disaster, but also seriously damage the well-organized development of water ecological environment.

(2) Serious damage of water ecological environment

In Guangxi, almost all the rural sewage is directly discharged into the river, According to Guangxi Zhuang Autonomous Region Water Resources Bulletin 2013, In July 2013, the river reach of Hejiang River in Liantang Town and Butou Town, Babu District, Hezhou City suffered from unexplained death of cage fish culture. It was found that the water quality of Hejiang river reach exceeded the standard of Cadmium and Thallium. The domestic sewage and industrial waste water in some rural area in Guangxi were directly discharged into rivers without treatment, especially in the river sections flowing through cities, where the water quality was poor, and there was a threat to the safety of some drinking water sources. The existing of illegal fishing led to the decline of fishery resources and a serious threat to the survival of wild species. In addition, the disordered sand mining in the river has damaged the environment of aquatic animals and plants. At the same time, the invasion of alien species has damaged the structure and function of the aquatic ecosystem, which has weakened the diversified characteristics of the river and caused serious harm to people’s health and ecological environment. According to the survey, in rural rivers, the number of fish stocks in rivers in Guangxi is almost two thirds less than that in the 1980s. The number of black carp, grass carp, silver carp and Bighead Carp decreased significantly, and the weight of the fish was significantly lower than that of the 1980s.

(3) The management system of ecological water network is not perfect

In Guangxi, the management system of ecological water network exists drawbacks. First of all, the inadequate management of water conservancy infrastructure construction, including shoreline collapse, sediment deposition and overgrown weeds, which lead to the shrinkage of river water storage space and the loss of ecological function of river corridor. The frequent floods during the wet season, and the weakening or even exhaustion of river base flow during the dry season. Second, there was a lack of the ability of overall deployment and industry supervision of ecological water network. There was a lack of unified administrative management for water ecological problems, but with a phenomenon of multi management. For example, for the same water ecological problem, the administrative authority was often dispersed to different departments such as water conservancy, agriculture, forestry, environmental protection, fishery, culture and tourism, and each department has not established a data sharing management platform, which was easy to cause unclear responsibilities, multiple politics, buck passing, information barrier and low efficiency. In addition, due to the lack of effective compensation mechanism for water ecological construction, the contradiction between water ecological protection and people’s life and production was difficult to coordinate comprehensively, which obviously weakened the protection of water ecology. Therefore, the construction of ecological water network management system was required to be further improved in order to realize the efficient management of modern ecological water network.

(4) The concept of water ecological protection is relatively out of date

Compared with the leading areas of water ecological protection in China such as Jiangsu, Zhejiang, the concept of water ecology in Guangxi was relatively out of date. First of all, the strength of water ecology publicity and education were not enough, so that the public doesn’t have the awareness of the value and importance of water ecology. Secondly, there was a lack of regional cultural characteristics in the construction of water ecological scenic spots, so that the investment of social capital was not enough. At the same time, the financial investment of government departments was very limited, resulting in the lack of effective investment and financing mechanism in the construction of ecological water network, and the lack of public concern about the ecological environment protection. The government is more inclined to display propaganda slogans, but neglects to ask the professional team of water ecological protection to guide the public on how to protect the water ecological environment.

4. Countermeasures of Ecological Water Network Construction in Guangxi Province

Under the guidance of the Chinese water management policy of “giving priority to water saving, spatial balance, systematic management, and two pronged approach”, combined with the overall situation of water resources development, utilization and industrial layout of regional economic development with Guangxi characteristics. Taking the integration of water resources, ecology, environment and economy as the construction goal, to build a new pattern of Guangxi ecological water network with complete system, coordinated functions, intensive and efficient development, green intelligence, well-organized regulation, safety and reliability.

4.1 Construction of Ecological Water Network with Interconnected Water Systems

The related administrators and water management
department need to strengthen the construction of different size water conservancy infrastructure and ecological corridor by learning from the effective investment and financing means of various regions. Gradually improve Guangxi water conservancy facilities network by integrating water diversion, water storage, water distribution, water supply and energy conservation. The government should lay emphasis on the construction of water source project, water conveyance channel and green ecological engineering with accelerating the development of ecological engineering industry. A regional data collection platform should be built by combining the digital watershed established by remote sensing satellite, UAV and other technical means with the existing monitoring stations to carry out real-time online supervision of all elements of basic data such as ecology, environment and hydrology. The optimal scheduling of ecological water network is expected to complete through data-driven, supply and demand analysis. Finally, the beautiful Guangxi with clear water and harmony between people and water will be achieved.

4.2 Comprehensive Management of Water Ecological Environment

The report of the 19th National Congress of the Communist Party of China \[26\] proposed “optimizing the ecological security barrier system, building ecological corridor and biodiversity protection network”. We should promote and implement the ecological protection and restoration projects of rivers and lakes, groundwater protection and restoration projects and the construction projects of ecological environment outside the river as soon as possible. Moreover, we should control the over exploitation and utilization of water ecology by human economic and social activities, explicitly prohibit fishing, hunting, illegal sand mining and illegal construction within the red line of the nature reserve, clarify the law enforcement power of the administrative agencies of the nature reserve, and improve the law enforcement ability of the law enforcement team. To ensure that the ecological water network has a complete ecological function.

4.3 Improve the Management System of Ecological Water Network

By improving the legal system, reforming the system, and improving the mechanism \[27\], we should implement the regulatory responsibility, and establish a comprehensive, efficient, and clear division of labor supervision system for the ecological water network system, by which the regulatory work has laws to follow and rules to follow. From the construction of ecological water network infrastructure to the post project operation and maintenance, the responsible departments and personnel should be clearly implemented to ensure the smooth operation of ecological water network and the comprehensive and stable monitoring data, as well as the perfect regional eco-environmental water security system. According to the development and utilization conditions of regional water resources and the water demand of ecological environment, the control index of water resources allocation and allocation should be clarified and the construction of dispatching operation and management system platform should be strengthened to promote the unified allocation of basin and regional water resources.
4.4 Strengthen the Propaganda and Education of Water Ecological Protection

Through cooperation with local colleges and social organizations, we encourage the concept of water ecological protection to enter the classroom to improve the public’s awareness of water ecological protection, and strengthen the training and education of water ecological protection management personnel, moreover, elaborately build water ecological park to make the tourists experience the natural customs of human water harmony, to publicize the important value of ecological protection to the whole society through Internet and we media, in addition, vigorously publicize the relevant administrative regulations and management regulations to improve the public’s sense of responsibility for the supervision of the ecological environment with forming a public opinion atmosphere that attaches importance to the protection of water sources and the protection of the ecological environment in the whole region.

5. Conclusions

The construction of ecological water network is a step-by-step system process. The ultimate goal is to establish a systematic ecological water network with complete system, coordinated functions, well-organized regulation, safety and reliability. In summary, firstly, enhance the construction of ecological water network, and realize the clear water intercommunication and data management platform construction of ecological water network. The second is to put an end to the destruction of the ecological environment by speeding up the work of ecological environment protection and governance and strengthening the law enforcement of management. The third is to perfect the relevant laws and regulations. The departments should implement the regulatory responsibility and security system. The fourth is to make greater efforts to publicize and expand social impact, meaning that enhance the awareness of the whole people to participate. By which the efficient and healthy development of ecological water network in Guangxi will be realized ultimately.

References


ARTICLE

Study of Bio-fertilizer Produced from Agro-waste (Sesame Straw) and Cow Dung Using *Eisenia fetida* and *Perionyx sansibaricus* in Arid Environment

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ABSTRACT

In this study, an analysis of organic fertilizer of an agro-waste (Sesame straw) plus cow dung was carried out using an epigeic earthworm species *Eisenia fetida* and *Perionyx sansibaricus*. Sesame straw is abundantly produced after each harvesting of the crop in Kharif season in arid region of tropical India. The compost produced in presence and absence of earthworm exhibit significant (\( P<0.001 \)) and non-significant (\( P>0.05 \)) changes in physicochemical properties respectively. In control bedding, the values of water holding capacity enhanced significantly (\( P<0.05 \)) by 1.28 fold, while organic carbon and C/N ratio decreased significantly (\( P<0.05 \)) by 19.93% and 31.25% respectively after 60 days of composting. Working of *E. fetida* in the bedding material showed significant (\( P<0.001 \)) difference in the level of pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, C/N ratio, available phosphorous and available potassium. After 60 days of working of *P. sansibaricus*, these physicochemical properties of the bedding substrate also changed significantly (\( P<0.001 \)). Analysis of vermibed showed a gradual increase in electrical conductivity, water holding capacity, total nitrogen, available phosphorous and available potassium by 1.51, 1.86, 1.95, 1.78 and 1.75 fold respectively. While the values of pH, organic carbon and C/N ratio declined by 9.30%, 41.80% and 71.48% respectively within 60 days of decomposition. Thus, *E. fetida* and *P. sansibaricus* can be applied for production of organic fertilizer of sesame chaff plus cow dung to fulfill the requirement of bio-fertilizers for organic farming and agro-waste management in arid environment.

1. Introduction

Agricultural sector contributes huge potential resources of plant nutrients in the form of wastes. Due to lack of appropriate disposal techniques, these wastes are either dumped or burnt in the agriculture fields after each harvesting. Which caused serious environmental pollution and diseases in subsequent crops. When the agro-wastes burnt after each harvesting in agricultural fields, it produces toxic gases caused air pollution, while dumping agro-waste releases greenhouse gases such as methane, H₂S etc. Pesticide treated decomposing organic wastes leached toxic elements to underground water and pollute the underground water resources as well as drained...
to rivers, lakes and ponds and caused eutrophication. There is tremendous increase in agro-wastes with the increase in agricultural production. These agro-wastes also contaminate the surrounding environment leading to diseases in animals and human. The wastes also act as a reservoir of fungal diseases of next crop. Thus, there is a warranted need of eco-friendly organic waste management technique to convert agricultural wastes into valuable biofertilizer [21].

A global problem for the disposal of wastes has arisen due to excessive growth in human population and consequent increase in industrial and agricultural activities [13]. Peculiar feeding and burrowing habits of earthworms make them most useful converters of wastes. A highly esteemed initiative has been done on commercial earthworm farming in other countries [31]. Preparation of nutrient rich organic manure from wastes can enormously help in rural based economy [29]. It has been well documented that earthworms can process all kinds of organic wastes such as household garbage, municipal wastes, sewage sludge, wastes from paper, wool and food industries, various organic wastes mixer [10,22,14]. Earthworm may also play an important role in pollution control using it in organic waste decomposition and production of biofertilizer [21,22].

During the last two decades, various workers from India and other parts of world have been involved in the work of recycling as vermicompost of different types of organic wastes from agriculture sector, cattle farm, industries, household, piggery farm and sewage [7,3,16,27,24,35,31,21,23,32]. But work on vermicomposting of a waste of specific crop is not reported. Therefore, in the present study, an agro-waste of sesame crop and cow dung mixed bedding material was decomposed to produce bio-fertilizer using earthworm species Eisenia fetida and Perionyx sansibaricus. Physicochemical properties of bio-fertilizer produced were estimated. A comparative study on sesame straw conversion efficiency of both the earthworms in laboratory conditions was planned and executed. The agro-waste management and bio-fertilizer production through vermitech technology are very much required for sustainable agriculture, human health, conservation of environment and ecosystem of the planet earth.

2. Materials and Methods

2.1 Collection of Materials

Sesame is an oil crop grown on a large scale particularly in western region of Rajasthan of India. Its straw was collected from agricultural farm of village-Chhila, tehsil-Phalodi of Jodhpur district. Sesame straw is dumped in huge quantity after each harvesting (27.0141 N; 72.2850 E) in Kharif season. Partially decomposed straw was collected from one season old heap. Air dried cow dung was also collected from the same site. The materials were filled in jute bags and brought to the vermiculture laboratory. Earthworm species Eisenia fetida was used from stock culture in cow dung, basically it was collected from Shri Kanhaiya Gaushala, Pal road, Jodhpur (26.23538 N, 72.96809 E). While, Perionyx sansibaricus was used from previously prepared stock culture in cow dung bedding material, originally collected from a sewage site of Nehru Park of Jodhpur city (26.27544 N, 73.01378 E).

2.2 Processing of Organic Waste Materials

The collected sesame straw and cow dung were left for one week at room temperature. Dried cow dung was powdered on hard surface, whereas sesame straw was grinded in mixer-grinder after thorough chopping. The powdery materials were sieved by 1mm (palatable size for earthworm) pore sized sieve separately and stocked in plastic bags for use in vermicomposting experiments.

2.3 Experimental Planning of Vermiculture

Triplicate sets of vermibeds (500 g dry weight each) were prepared using powdered sesame straw and cow dung in 1:1 ratio in plastic tub having 5 litre capacity. The material was moistened to stabilize within 2 days. In the experimental set, 25 clitellates worms of each species (E. fetida and P. sansibaricus) were inoculated separately. One set of control bedding material (without earthworm) was also maintained parallel. The culturing plastic containers were perforated 2-3 places to drain excess water. However, leached water was collected in other containers and reused for watering the vermicombed so as to prevent the washout of nutrients. The vermiculture experiments were conducted for 60 days. During composting period, moisture was maintained between 60 to 70 percent by sprinkling water on the bedding regularly. The temperature of vermicombed was maintained 30± 3 °C and wet Jute cloth was used to maintain the temperature of vermicombed.

2.4 Analysis of Bedding Materials

During decomposition, changes in pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, carbon/nitrogen ratio, available phosphorus and potassium were observed after an interval of 15 days of worm working viz., 0, 15, 30, 45 and 60 day. For this purpose, 10 g dry weight basis samples were collected...
from each experimental as well as control bedding in plastic pouches. The pH and electrical conductivity of bedding materials were measured with the help of a digital pH and EC meter respectively. Walkley-Black method was used for determination of organic carbon \[13\]. Total nitrogen was measured by Kjeldahl method as described by Jackson employing Kel plus system (Kes-20 and Distyl-EM) \[11\]. Available phosphorus was estimated as described by Anderson and Ingram \[1\] and exchangeable potassium was determined by Simard method \[14\]. The temperature of vermbed was recorded with the help of thermometer (MEXTECH multi-thermometer). Moisture of bedding substrates was estimated by oven drying method.

2.5 Statistical Analysis of Data

Triplicate set of data were collected by analyzing each set of beddings. Standard error of mean (SEM) was calculated for the triplicate data. A one way analysis of variance (ANOVA) was performed to test the level of significance in physicochemical properties of control and experimental bedding substrates.

3. Results

Sesame straw plus cow dung bedding material with and without earthworm exhibited significant changes \((P<0.001)\) in physicochemical properties with respect to decomposition period. In control bedding the values of pH, electrical conductivity, total nitrogen, phosphorous and potassium did not vary significantly \((P>0.05)\). While water holding capacity enhanced significantly \((P<0.05)\) by 1.28 fold. Organic carbon and C/N ratio varied significantly \((P<0.05)\) by 19.93% and 31.25% respectively after 60 days.

Working of \(E.\text{fetida}\) in the bedding material showed significant \((P<0.001)\) difference in the level of pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, C/N ratio, phosphorous and potassium. The pH value decreased by 10.95%. Similarly, organic carbon reduced by 44.09% and C/N ratio by 78.10%. On the other hand, vermicompost showed 1.83, 1.92, 2.65, 2.10 and 2.14 fold increases in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium respectively after 60 days of the earthworm working as compared to initial values.

After 60 days of working of \(P.\text{sansibaricus}\), physicochemical parameters of the bedding material changed significantly \((P<0.001)\). The vermbed showed a gradual increase in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium. However, values of pH, organic carbon and C/N ratio decreased by 9.30%, 41.80% and 71.48% respectively within 60 days of decomposition. Unlike these, the compost showed 1.51, 1.86, 1.95, 1.78 and 1.75 fold increase in electrical conductivity, water holding capacity, total nitrogen, phosphorus and potassium respectively after 60 days working of \(P.\text{sansibaricus}\) as compared to 0 day level (Figure 1).

4. Discussion

Physicochemical properties of sesame straw plus cow dung bedding material showed different trends in control (without earthworm) and experimental (with earthworm) groups (Figure 1). The results obtained indicated reduction in pH, organic carbon and C/N ratio of vermicompost as well as control compost at the end of composting. Control, \(E.\text{fetida}\) and \(P.\text{sansibaricus}\) processed composts showed 3.80%, 10.95% and 9.30% decreases in pH respectively. Higher reductions were observed in \(E.\text{fetida}\) followed by \(P.\text{sansibaricus}\) and control. However, pH of control bedding material did not vary significantly \((P>0.05)\) with respect to initial level. During the composting process the pH level declined from alkaline to acidic close to neutral medium in vermicompost. This may be because of enhanced decomposition and mineralization by earthworm and production of acids during the decomposition. It can be supported by the observations of Ndewga et al who described pH shift toward acidic condition due to mineralization of nitrogen and phosphorus into nitrates/ nitrites and ortho-phosphate and bioconversion of organic materials into intermediate species of organic acids \[19\]. Similarly, other workers \[8,5,6,19\] also concluded that production of CO\(_2\) and organic acid by microbial decomposition lowered the pH of substrate.

Organic carbon in \(E.\text{fetida}\) and \(P.\text{sansibaricus}\) induced compost decreased sharply as compared to their starting levels by 44.09% and 41.80% respectively. The control bed also showed a decline in organic carbon but degree of decrease was significantly \((P<0.05)\) lesser than vermicompost after 60 days period of decomposition. Present results are in agreement to the report of Elvira et al who showed that large proportion of organic matter in the initial substrate was as loss as CO\(_2\) between 20 to 43 percent as organic carbon by the end of vermicomposting \[5\]. Nath et al observed that total organic carbon declined (45 to 50%) drastically as compared to their initial levels \[19\]. Likewise, other workers also reported 20 to 45 percent loss of total nitrogen in the form of CO\(_2\) from agriculture wastes and industrial sludge during vermicomposting occurred \[5,15,36\].

Value of electrical conductivity of the bedding material
Figure 1. Showing the changes in pH, Electrical conductivity, Water holding capacity, Organic carbon, Total nitrogen, Carbon/Nitrogen ratio, Phosphorus and Potassium during the decomposition of sesame straw plus cow dung using earthworms (*Eisenia fetida* and *Perionyx sansibaricus*).
increased as compared to initial level. The values of EC in control, *E. fetida* and *P. sansibaricus* increased by 1.07, 1.83 and 1.51 fold respectively as compared to 0 day of composting period. Possibly it was due to decomposition of organic matter and release of salts during mineralization process. Increase in electrical conductivity might have been due to the loss of organic carbon and release of different salts in available forms \[18,29\]. In contrast to this, Nath *et al* reported a decrease in EC during vermicomposting \[19\].

Total nitrogen level was increased after 60 days of composting of sesame straw plus cow dung bedding material. The level of nitrogen content in control bedding substrate enhanced by 1.16 fold after completion of composting duration. However, *E. fetida* and *P. sansibaricus* worked compost indicated by 2.65 and 1.95 fold increase in nitrogen content respectively. Present study revealed that organic waste conversion efficiency of *E. fetida* is better than *P. sansibaricus*. Nitrogen enhancing capacity of both species of earthworm was significantly higher than control (microbial decomposition) after 60 days of composting period. It indicates that *E. fetida* feed voraciously on organic waste rich materials. Other workers reported that earthworm increases the nitrogen content due to nitrogen mineralization from organic matter in the soil because nitrification is enhanced in worm casts \[20\]. Some workers also suggested that *E. fetida* in organic waste increased nitrogen level significantly \[9\]. Increasing trend of nitrogen in vermicompost was also reported by many other workers \[36,19,12\].

C/N ratio, available phosphorus and potassium are other widely used indicators for maturity of organic wastes. C/N ratio was drastically declined in vermicompost as compared to control substrate. Senesi reported that decline in C/N ratio to less than 20 which indicates an advance degree of organic matter stabilization and reflects a satisfactory degree of organic waste \[19\]. The C/N ratio decreases sharply during vermicomposting process \[14,36,19,25\]. Available phosphorus and potassium increased significantly (P < 0.001) in vermicompost as compared to their starting levels. Phosphorus content increased by 2.10 and 1.78 fold in the bedding material with *E. fetida* and *P. sansibaricus* respectively in relation to 0 day composting. Similarly, potassium showed 2.14 and 1.75 fold increase in the bedding sets. The possible cause of increase in nutrients may be crumbling in alimentary canal of earthworm which breakdown the large particles into small molecules and microbial action. Similar results have been obtained by other workers \[18,29,4\]. Passage of organic residue through the gut of earthworm releases nutrients including phosphorus. Release of phosphorus in available form is performed partly by earthworm gut phosphatases and further release of phosphorus may be attributing to phosphorus stabilizing microorganism present in worm cast \[17\].

5. Conclusions

An agro-waste (sesame straw) and cow dung have been converted into a valuable bio-fertilizer using two epigeic earthworm species *Eisenia fetida* and *Perionyx sansibaricus* in arid area of India. Changes in physicochemical properties viz., pH, electrical conductivity, water holding capacity, organic carbon, total nitrogen, carbon-nitrogen ratio, available phosphorus and available potassium of bedding substrates were estimated at 15, 30, 45 and 60 days of time interval. It was observed that *E. fetida* was insignificantly more potent in decomposition of this agro-wastes as compared to *P. sansibaricus*. The both earthworm species may be applied for conversion of huge amount of agro-waste into organic fertilizer for sustainable agriculture and soil ecosystem.

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References


ARTICLE
Assessment of Urban Greenery Status in Major Cities of Oromia, Ethiopia

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ABSTRACT
This work aims at studying different green spaces’ experiences in developed countries and extrapolates the experiences to Oromia cities in Ethiopia; in order to investigate and promote greenery infrastructure in selected cities. To do that greenery practice performance data were collected in four cities, which were classified into two groups as good and weak performers. As a result, Adama and Bishoftu cities were good urban greenery performers whereas Burayu and Sebeta were weak performers. The cities were also selected non-randomly to investigate the current urban greenery practice and different green areas in each city. Eight green areas were taken as samples for observation, where qualitative and quantitative data were collected from primary and secondary sources. The assessment of data confirmed that green areas along the roadside, recreational parks, open areas, and nursery sites existed in most cities. The urban plan of some cities does exclude most green area components. Greenery sites in Bishoftu and Adama are relatively better, while in Burayu and Sebeta urban greenery are highly abused for changing to another type of land use, e.g., residential and institutional areas. The technical skills of tree planting, care, protection, and management were also observed as a collective resource.

Keywords: Urban greenery, Per-capita, Green space, Tree nursery, Urban plan

1. Introduction
Today more than 50% of the world’s population inhabits urban areas [1,2]. Current urbanization processes indicate that additional three billion person will live in cities by 2050, increasing the urban population proportion worldwide to two-thirds [3,4]. According to the report [5], human settlements are complex, involving socio-ecological systems that are dependent on the health of natural environments for ongoing sustainability. Thus, planning for sustainable cities is a complex process addressing all economic, environmental and social sustainability [6]. The greenery is consisted of vegetation in all urban parks, residential recreation areas and others any trees and shrubs are planted within demarked cities. Urban Green Infrastructure is an evolving concept to provide a biotic and cultural function with sustainability [7]. It emerges as an active term of reference in project development planning [8]. Hence, greenery has become an important policy initiative in many cities internationally, and has been used to address different environmental and social concerns today [7].

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Greenery is an emerging planning and design concept that is principally structured by a hybrid hydrological/drainage network. Complementing green areas and linking them with built infrastructure could provide ecological functions \(^9\). Currently, several studies confirmed urban green spaces as a resource in improving the environmental quality, promoting public health and providing valuable ecosystem services, urban tourism, active and passive recreations to urban dwellers \(^{10,11}\). Most importantly, it is reduced wind erosion and flooding which is the part of disaster abatement. Therefore, green areas should be an integrated concept in terms of single ideology, respecting ecology and mimicking nature \(^9\). Similarly, the current growth agenda may hopefully require the identification and targeting of land for new green infrastructures. To address, the importance of greenery to be incorporated in urban planning. However, along with discovering political and economic mechanisms for land acquisition in and around growing urban environments, sound ecological decisions will need to be made at a landscape scale \(^9\).

One of the purposes of this review is to assess different green area experiences which are found in developed countries and to extrapolate those experiences to developing countries, especially Ethiopia. Finally, this work attempts to bridge further source of information and endeavours to fill the existing research gaps about the green area issues. Green spaces could help urban areas adapt to the impact of climatic change regardless of whether they are parks, private gardens or street trees. However, the size, quality, and shape of a space, vegetation type and proportion of coverage all might influence the level of impact. The main problems of the study for Oromia cities are the challenges of land grab squatters, weak policy intervention, institutional capacity, less participation, political priority, etc. Only few studies have been conducted in urban areas in combating climate change and beautification value it has. The published information is extremely scarce on the root causes and constraints hindering the greenery development mainly in Oromia urban lands, no matter they are newly established or previously existed. The objective of this survey study is to assess status of urban greenery space development of Oromia cities. Based on existing greenery areas, to recommend the best option for further development for each cities according to their suitability of agroecology.

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**Figure 1.** Location map of the studied cities

**Table 1.** Description summary of studied area

<table>
<thead>
<tr>
<th>Cities</th>
<th>Altitude (m)</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Temperature (°C)</th>
<th>Rainfall (mm)</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adama</td>
<td>1620</td>
<td>8°32′24″ N</td>
<td>39°16′12″ E</td>
<td>21</td>
<td>838</td>
<td>150,228</td>
</tr>
<tr>
<td>Bishoftu</td>
<td>2135</td>
<td>8°43′26″ N</td>
<td>38°56′24″ E</td>
<td>20</td>
<td>1076</td>
<td>85265</td>
</tr>
<tr>
<td>Burayu</td>
<td>2600</td>
<td>9°02′30″ N</td>
<td>38°03′30″ E</td>
<td>14-22</td>
<td>1188</td>
<td>76,681</td>
</tr>
<tr>
<td>Sabata</td>
<td>2065</td>
<td>8°53′38″ N</td>
<td>38°35′11″ E</td>
<td>13-25</td>
<td>1605</td>
<td>97,554</td>
</tr>
</tbody>
</table>

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2. Methodology

Adama, Bishofo, Sebeta, and Burayu cities are selected for this study. Adama and Bishofo are located in the East showa zone whereas the other two cities are located within the Finfinne Special Zone of Oromia Regional State, in central Ethiopia (Figure 1). The area and description of the study are presented in (Table 1).

2.1 Sample

A field survey was conducted on the general physiognomy of urban greenery in Oromia. Four cities namely Adama, Bishofo, Sebeta and Burayu were selected as the sampled study areas for urban greenery performance and accessibility. A stratified sampling method was employed in assessing greenery practice performance. Four cities were classified into two groups as good and weak performers. Considering different standards, Adama and Bishofo were selected as good urban greenery performer whereas Burayu and Sebeta were selected as weak greenery practice performing cities. A greenery site in the cities was also selected non-randomly to review the current urban greenery practice. Eight green areas in each city were taken as samples for observations. Respondents were also selected purposely according to the positions and duties in the corresponding departments. Eventually, questionnaire was given to the selected respondents from four cities.

2.2 Data Collection

Various types of qualitative and quantitative data were collected from primary and secondary sources. Secondary data were collected from the municipal administration department, urban greenery department and different stakeholders. Most data including agro-ecological, socio-economic and urban green infrastructure were collected through structured open and closed ended questionnaires, and personal perceptions. The comprehensive questionnaire was spread to the respondents from four cities to be filled with great care and attention. After filling the questionnaire from the individual’s, the next part was having a discussion about the challenges and development of urban green space from the focus groups in each city which was comprised of staff members of urban greenery department. The number of participants in the focus group discussion was four in Adama, five in Burayu, six in Bishofo and Sebeta cities in reference to the number of available staff members in each city. Both direct and indirect participant observations were made in all the cities at selected green space. During this survey, intensive observations were carried out on species compositions, structure of urban greening and some physical challenges. Secondary data were collected from various researches, and reports. Urban greenery standards and practices in other Ethiopian cities were also reviewed as well as policies and legal frameworks of greenery space. Greenery strategic plan, urban greenery plan and reports of the studied cities were also collected and analyzed to review the current and future greenery practices of the cities.

2.3 Data Analysis

The representative biophysical data collected from the studied cities were subsequently analyzed using Microsoft excels. Arc GIS software was used to analyze greenery space areas in hectare. Qualitative data were also analyzed using descriptive and explanatory methods.

3. Results and Discussion

The greenery areas on the urban plan in Bishofo, Burayu, and Sebeta are 3,903.67 ha, 2,982.7 ha and 2,234.19 ha respectively. The lands developed for green space is 1,172.38 ha in Adama, and 612.96 ha in Bishofo whereas no lands have been developed in Burayu and Sebeta. Hence, the per-capita urban greenery coverage per Metric Square for Adama and Bishofo are 0.0038 m² and 0.0033 m² respectively which are unable to meet the minimum standard proposed by the World Health Organization (WHO) [12]. One of the study in other cities of the country showed that, Shashemene, Dese, Jijiga, Dire Dewa, and Bahir Dar cities are 1.9 m², 3.1 m², 3.8 m², 5.6 m², and 8.2 m² of urban green spaces per person respectively in 2013 [13,14] are greater than the study cities. Only a few green infrastructure components were established in Oromia cities. As confirmed by the assessment, green areas along the roadside, recreational parks, open areas, and nursery sites existed in most cities. The cities plan does include most of the green space components. Greenery sites in Bishofo and Adama are relatively better. However, the greenery sites in Burayu and Sebeta are highly abused and changed to residential and institutional area. No concrete data were supplied by the city administration during this work. All the data were collected from personal observations and secondary sources from Oromia Urban Plan Institute.

3.1 Challenges of Urban Green Space

Problems related to the technical skills of tree planting, care, protection, and tree management were observed in this work. The survey confirmed that the forestry practices in Oromia cities suffered from the following: arboriculture challenges, canopy space challenges, poor.
3.2 Observed Species in the Cities

3.2.1 Adama

Various trees, shrubs, grass, and flowers were planted in Adama city in different green spaces. Current planted tree species included *Acacia S.*, *Acacia A.*, *Acacia D.*, *Accacia T.*, *Alternata*, *Araucaria A.*, *Azadrachta I.*, *Balanites A.*, *Borassus A.*, *Bougainvillea S.*, *Boxus S.* (hedgerow plant), *Calleste mon C.*, *Carica P.*, *Cassia P.* (fruit trees), *Cassia S.*, *Casuarina E.*, *Coffee A.*, *Cordia A.*, *Croton M.*, *Cupressus A.*, *Cupressus P.*, *Cymbopogon M.* (tessar), *Dahlia Sp.*, *Delonix R.* and *Dovyalis A.*. The dominant species observed in most parts of the city are *Acacia A.*, *Borassus A.*, *Araucaria A.*, *Callistemon C.*, *Casuarina E.*, *Delonix R.*, *Grevillea R.*, *Hibiscus R.*, *Jacaranda E.*, *Mangifera I.*, *Melia A.*, *Moringa S.*, *Nerium O.*, *Pennisetum C.* (Kikuyu grass), *Persea A.* (Avocado), *Phoenix R.*, *Shinus M.* and *Spathodea N.* It was observed that in Adama city, different types of urban greenery space were not initially considered in the urban plan. Therefore, the city council needs to revise the urban plan and assign some spaces to greenery components.

3.2.2 Bishoftu

*Gravillia R.*, *Casuarina E.*, *Melia AZ.*, *Olea A.*, *Delonix R.*, *Jacaranda M.*, *Spathodia N.*, *Schinus M.*, *Phoennex R.*, *Cordia A.*, *Acacia S.*, *Acacia M.*, *Eucalptus Sp.* and *Golden Flower* tree species and turf development are found in the city greenery areas. These tree species are planted in the spaces illustrated on the city structural plan. Similar to Adama city, Bishoftu has left a green space on its urban plan. However, the scientific approach was not applied during the tree plantation process. In brief, different lands are allocated for the riverside, roadside, forest, open areas, mixed residential, plant’s area, park, urban agriculture and lake greenery components. Forest has the biggest green space that was considered by Bishoftu city municipality. The least prioritized green infrastructure components in the city were roadside. Other greenery components like cemetery area, religious area, institutional and organizational area, river buffer zone, greenbelt plaza, and public area are not considered in Bishoftu city’s structural plan. Though Bishoftu city prepared spaces for many greenery components, only roadside, park, and lake components are developed now.

3.2.3 Sebeta

Only a few of the greenery site components are developed in Sebeta roadside open areas, mixed residential and urban agriculture are highlighted on the city structural plan. There is no adequate information available on the types of trees and details of green infrastructures in Sebeta city. The city administration has no adequate greenery practices. According to the city structural plan, 128.9, 1810.9, 7302 and 294.39 hectares are allocated for roadside, open areas, mixed residential and urban agriculture green infrastructure components, respectively. However, there is no greenery practice that was taken on the ground development.

3.2.4 Burayu

The greenery site components are not clearly observed on the urban plan. Similar to the situation in Sebeta, there were no adequate information presented on the types of trees and details of green spaces in Burayu and not adequate greenery practices.

3.3 General Gaps and Strength of Urban Greenery Components

The greenery components like median strips, squares/plaza, drainage areas, roadsides, institutional area, home gardens, nursery sites, communal housing area, rivers, river buffer zones, green belts, parks, sports field, cemeteries, and urban agricultural sites were assessed in this study. Majority of these components in the various
cities have not been actualized. As a consequence of lacking knowledge and awareness, shortage of finances, less political commitment and poor legal framework, the greenery coverage is decreasing in most cities. The designed greenery space is changed to other land use or practically undeveloped. The situation of greenery sites in studied cities showed similar trends that have been observed in other cities of the country. The practices in Adama and Bishoftu are relatively better compared to the other two cities in Oromia. The development of the median strips in the cities is quite appreciable as compared to the other types of green space. Most of the greenery components are indicated on their structural plan and lands are allocated accordingly. It also created job opportunities for small and micro enterprise associations and became an income source for many young individuals. In Adama, there are 14 associations with a total of 188 members who are working on greeneries and the majority of them are 21 to 35 years old. The median strips in Adama and Bishoftu were well managed by the associations and supervised by urban greenery and beautification team. The nursery was established for raising different seedlings which can adapt to the hot climate of the city. The city nursery site was well designed, fulfilling the established criteria. In Adama’s nursery sites, 750,000 seedlings of 30 different species have been raised annually. But no information on the greenery practices was available as for Burayu and Sebeta cities although the green spaces have been indicated in their structural plan.

3.4 Purposes of Managing Green Area

Urban greenery resources in and around densely populated places are well-known by providing different local values and playing an important role in improving living conditions. As explained in different kinds of literature, and observed in Oromia cities, the greenery resources were providing different goods and services, creating job opportunities, moderating harsh urban climates, conserving biodiversity and contributing to better public health in the cities. In spite of its various scientific purposes and benefits, the development of greenery spaces has not been understood well in most cities. This assessment confirmed that the purpose of developing different greenery components in studied cities was not well understood. According to data observed from the Adama and Bishoftu cities, the types of plants and ground covers used for those green areas were not scientifically approved. Some of the observations in all the cities were; unsuitable agro-ecological zone of the tree species, inappropriate type of trees, and tree planting without purpose (Table 2).

The major bottlenecks that hinder further development of this sector were technical limitations, awareness, and participation of public and stakeholders, attitudes, limited resources, weak institutional setup, policy and legal framework and lack of political commitment.

On the other hand, there is a limited amount of funds allocated for greenery in the municipal sector. The political leader’s paid little attention to the development of greenery landscapes hence leading too few of annual budgets allocated as compared to the situation of the workload. Besides, the land is not well protected under the demarcation. The allocated greenery site can be suddenly changed to another land use system sometimes. Moreover, there is no policy and legal framework that can protect and keep the urban greenery in Oromia cities. Nevertheless, there are policies, urban greenery strategies, proclamations, and standards that can enhance greenery development at the federal level.

3.5 Tree Nursery Site

Nursery site was well-known in providing opportunities

<table>
<thead>
<tr>
<th>No.</th>
<th>Trees</th>
<th>Shrubs</th>
<th>Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Acacia saligna</em></td>
<td><em>Carissa edulis</em></td>
<td><em>Cymbopogon martini</em></td>
</tr>
<tr>
<td>2</td>
<td><em>Acacia tortilis</em></td>
<td><em>Dovyalis abyssinica</em></td>
<td><em>Dahilia sp.</em></td>
</tr>
<tr>
<td>3</td>
<td><em>Azadirachta indica</em></td>
<td><em>Phoenix reclinata</em></td>
<td><em>Pennisetum clandestinum</em></td>
</tr>
<tr>
<td>4</td>
<td><em>Cordia africana</em></td>
<td><em>Dovyalis abyssinica</em></td>
<td><em>Arundo donax</em></td>
</tr>
<tr>
<td>5</td>
<td><em>Croton macrostachyus</em></td>
<td><em>Psidium guajava</em></td>
<td><em>Gazania thermalis</em></td>
</tr>
<tr>
<td>6</td>
<td><em>Cupressus pyramidalis</em></td>
<td><em>Punica granatum</em></td>
<td><em>Aloe vera</em></td>
</tr>
<tr>
<td>7</td>
<td><em>Spathodea nilotica</em></td>
<td><em>Rosa abyssinica</em></td>
<td><em>Musa enseta</em></td>
</tr>
<tr>
<td>8</td>
<td><em>Delonix regia</em></td>
<td><em>Hibiscus rosasinensis</em></td>
<td><em>Gazania thermalis</em></td>
</tr>
<tr>
<td>9</td>
<td><em>Ficus vasta</em></td>
<td><em>Lantana montevidensis</em></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td><em>Mangifera indica</em></td>
<td><em>Coffee Arabica</em></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td><em>Persea americana</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Major various species observed in the study area
for potential sources of seedlings and cultivating the locally adaptable tree species [12]. Bishoftu and Adama have standard nursery sites even though dominantly exotic species have been grown in it, whereas the nursery site was not well developed in Burayu and Sebeta. There were sample nursery sites under standard conditions in Burayu and Sebeta but does not fulfil the following conditions as presented in a nursery catalogue: human labour, working conditions, personal protective equipment, accessibility, infrastructure, species selection, and management system. The organizational structure of greenery sector in Oromia cities is one of the bottlenecks for implementation of different greenery components according to the required standards. There is no adequate trained human labour allocated for greenery sector in all cities. The institutional structure contains two or three persons, supervised by town municipalities to undertake urban greenery and beautification process. However, the staff members allocated for greenery jobs are unqualified persons without knowledge and skills of greenery in the field.

In Adama and Bishoftu cities, there are some micro and small enterprises that can bring job opportunities for the urban dwellers even though they are not enough to address the depth of greenery works in the cities. However, these enterprises are not found in Sebeta and Burayu cities. Bidding for development of the green area by municipality focuses only on the least cost approach thus compromising on the quality.

4. Conclusions

The investigations and analysis on this survey have come to these conclusions. The current urban greenery coverage in Oromia cities is smaller than the given quality and size an international standard value of UN-HABITAT and Ethiopian Federal Democratic Republic urban greenery standard value [11,12]. The per-capita international urban greenery standards of the globe and Ethiopia are 20 and 9 m² per person, respectively. However, the average per-capita urban greenery share of Oromia is 0.0035 m² per person and also poorly managed. The green space in cities of the region is also decreasing gradually. The structural plan of most cities has indicated the space for greenery without highlighting the names of different green area components clearly. The current practice of greenery in most cities is insignificant. In some cities, greenery spaces have been changed to other purposes while in other cities the development of greenery spaces has not been started yet. Some of the bottlenecks that have contributed to the substandard urban greenery in Oromia cities are: weak institutional setups, lack of training, flimsy policy and legal frameworks, sleazy political commitment, reluctant of public and stakeholder’s awareness and participation. The authors are strongly recommended to the responses cities municipality to manage and protect the existing greenery areas and allocate sufficient greenery areas for further development.

References


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**A Review of Research on Ecological Economics Based on Bibliometrics**

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**1. Introduction**

Ecological economics is based on saving the ecological environment, focusing on the principles of ecological economics, using systematic engineering methods to change production and consumption methods, discovering available global resources, and developing industries that are mutually beneficial to the economy and ecology, to achieve the goal of harmonious progress between the ecological environment and economic development. Traditional economic models have been replaced [1]. In the early stages of human development, human beings focused on economic development issues and ignored the relationship between the ecological environment and economic development, which led to severe environmental pollution problems, environmental damage, and a serious waste of resources. Therefore, to solve the problem between the ecological environment and economic development, scientists put forward the concept of “ecological economics” in the early 1960s. The development of ecological economics has been a significant strategy in the 21st century [2].

From the 1960s to the 1970s, the unified point of view...
between the new classical economic theory and natural scientists was that technology alone could not solve population and pollution problems. The contradiction between the ecological environment and the economy can be solved effectively by adopting ethical laws and economic adjustment measures. Since the 1970s, scientists have done much work on the theory and application of the restoration and reconstruction of disturbed and damaged ecosystems. The report “There Is Only One Earth,” published in 1972, focused on the earth’s future. It analyzed today’s environmental problems from social, political, and economic perspectives. It reported on the rapid population growth, waste of resources, the impact of industry and technology, unbalanced development, and the dilemma of urbanization worldwide and revealed why human environmental resources have been destroyed and the global ecosystem were damaged to remind people of the finiteness and changeability of living places. Currently, we systematically study the origin of the ecological system’s restrictions on humans. In 1986, Vitousek combined the primary production capacity and carrying capacity of the natural system, and people began focusing on the ecological system’s constraints on the human system and discussing the ecological carrying capacity of human society. In 1987, some scholars proposed a combination of economy and ecology. The ecological environment and economy are interdependent and mutually promoting. The higher the degree of coordination, the more probably sustainable development can be achieved. The International Society for Ecological Economics (ISEE) was established in the late 1980s and was founded by more than 50 scientists. After founding ecological economics, they began the “Ecological Economics” magazine in 1989, formally establishing ecological economics. In 1991, Pearce divided the development into two categories: strong sustainability, and weak sustainability given the difference in the treatment of natural assets and artificial assets, which can be regarded as a milestone in the study of sustainable development indicators. However, China proposed the study of ecological, economic issues and established ecological economics in 1980. China’s eco-economic development is divided into five stages: the first stage was of poor development from 1985 to 1992, the second stage from 2003 to 2009, the third stage performed well in the early stage of reform (1981-1984), the fourth stage was from 1993 to 2002, and the fifth phase was from 2010 to 2012. Research on the high-quality development of the ecological economy has emerged in academic circles, mainly from the connotation of the ecological economy and green development, the model and development path of the ecological economy, etc. Different research methods for the sustainable development of regional ecological economics exploring the coordinated development and green and low-carbon cycle level have attracted substantial political and policy attention. Nowadays, China’s economy is shifting from high-speed growth to high-quality development, striving to achieve a coordinated social economy and ecological environment. At present, some studies have carried out high-quality research in the ecosystem and ecological security, high-quality economic development and its driving forces, and achieved a series of research achievements. China is in a critical period of transformation of the economic development mode, and regional ecological carrying capacity and economic growth are rapid. The contradiction between the bearing capacity of a region and ecological development is still prominent, and a contradiction between ecology and economy still exists. Domestic and foreign scholars have conducted many useful explorations and studies on the coordinated development of the ecological environment and economy. Scholars such as Suo Cheng analyzed the distribution pattern of resources, ecological environment, and social economy of the Silk Road Economic Belt in 2015 and proposed the main models and paths for the sustainable economic development of the Silk Road Economic Belt. In 2018, Song analyzed the coordinated development of the social economy and ecological environment in the Weihe River Basin. Tian used simulation models to analyze developed cities in 2019 and predicted the possible interaction between the urban economy and the ecological environment.

Discussing the research hotspots and frontiers in this field at home and abroad is conducive to grasping the latest progress of ecological economic research and can provide literature references for follow-up related research. To gain a deeper understanding of the research hotspots in ecological economics, this study uses a scientific measurement method and CiteSpace to visualize the scientific knowledge map. It analyzes the development status of the ecological economy research field at home and abroad, from keywords, research institutions, and authors, to introduce the relevant information of the main research and analyze the main hot topics.

2. Data Sources and Analysis Methods

In this article, data in the field of ecological economy are obtained from the Web of Science database, with the theme of “Ecological Economy”, the time range of “2011-2020”, and the Index: topic = (“ecological economy”). After searching and sifting conference records and book
chapters, 3074 papers were obtained. And we found that several related keywords included, such as ecological economics, industrial ecology, ecological modernization and so on.

We exported the searched documents to a plain text format through the search results obtained in the Web of Science database. We then imported the data into the CiteSpace software for analysis to draw a keyword co-occurrence map, a keyword cluster map, a keyword emergence intensity cluster map, a keyword Timeline map, a published author map, and a diagram of institutional cooperation. In the CiteSpace software toolbar, select Import/Export to enter the Data Processing utility page, click WOS, select the corresponding folder in the Data Directories, and then the WOS column. Click Remove Duplicates from 2011 to 2020 in ecological economics. The data of the number of posts issued by Excel are processed to obtain the post trend chart (Figure 1).

![Figure 1. Trends of publications in the research field of ecological economy from 2011 to 2020](image)

3 Results and Discussion

3.1 Analysis of the Number of Papers

By analyzing the retrieved documents in CiteSpace, the number of papers published on ecological economics from 2011 to 2020 was obtained, and a line chart of the publication trend was made using Excel (Figure 1). Through the broken line, we found that from 2011 to 2020, the number of published documents in ecological economics has shown an increasing trend. However, the period from 2011 to 2017 was a slow development stage with a slight increase. Overall, there was a rapid development trend from 2017 to 2020. From 2011 to 2020, the number of hot spots in ecological economics is increasing annually. The number of articles published has increased from more than 50 to nearly 680.

3.2 Analysis of Keywords

We used CiteSpace to construct four maps of ecological economics, namely the keyword co-occurrence map (Figure 2), the keyword key node cluster map (Figure 3), the keyword emergence intensity cluster map (Figure 4), and keyword Timeline map (Figure 5). Figures 2, 3 and 4 show that sustainability is the current research hotspot in ecological economy. The main purpose of studying ecological economy is to deal with the relationship between ecosystems and economic systems. According to the current economy, scientists propose solutions to the existing problems in social development to coordinate the economic society and the ecological system and orderly achieve the goal of sustainable ecological and economic development. Ecological economics has been a long-term concern for human society, which can be seen in the establishment of the international society in 1988, the formal institutionalization of ecological economics [14]. Ecological economics is a discipline that studies the structure, function, and movement laws of the composite system of ecosystems and economic systems and belongs to a branch of economics. It is based on the idea of uniting academicians from different backgrounds, to encourage new ways of thinking about the relationship between ecosystems and economic systems. The development of the ecological economy has always attracted attention. Keywords are the core of the article. By analyzing keywords, we can study the research hotspots within a certain period. According to the keyword co-occurrence map (Figure 2), the number of nodes in the map was 503, the number of connections was 710, and the network density was 0.0056. Both the node size and keyword size in the map indicate the frequency of occurrence of a keyword. The larger the value, the higher the frequency of the word, which can be used as a research hotspot for analysis. The keyword that appears most frequently in this research field is sustainability, followed by management, climate change, and impact. According to the key node cluster diagram of keywords (Figure 3), the first ten cluster words are set, namely carbon dioxide emission, metabolic transition, hospitality model, forest carbon project, degrowth activist and circular economy indicating that the current research is mainly focused on sustainable development, paying close attention to the issue of carbon dioxide emissions and look for a sustainable development model. In 2015, the United Nations put forward the 2030 commitment to achieve 17 sustainable development goals and 169 specific goals. These goals are divided into sustainability dimensions in the scientific literature: economic, social, and environmental [15,16]. Thoroughly
solve social, economic, and environmental development issues in an integrated manner, thereby turning to the path of sustainable development. Due to the efforts of the United Nations Sustainable Development Goals (SDGs-6, 7, 8, 12, and 13), these goals have solved the problems of clean water, energy access, responsible consumption, and climate change mitigation. The keyword emergence intensity cluster map (Figure 4) selects the emergence intensity of the first 22 keywords for analysis. According to the keyword emergence intensity cluster map (Figure 4), the keyword “ecological economics” (2011-2016) has the longest emergence time, indicating that the research enthusiasm for “ecological economics” lasts the longest. Among them, it is worth noting that the keyword “industrial ecology” appeared in 2012. The concept of industrial ecology first appeared in the 1989 “Scientific American” magazine. While mankind vigorously develops economy and technology, the problems of resource shortage and industrial pollution have also followed, restricting the development of human society. Industrial Ecology (IE) is a theory about the concept and implementation of sustainable development. In the past thirty years, scholars have conducted a lot of theoretical and applied research on IE. Especially in the past ten
years, a large number of papers have been published in the field of industrial ecology, and the cooperation between authors has become more extensive, and there are clearer and more specific research contents and methods for industrial ecology. In recent years, China has gradually paid attention to research in this field [18]. The field of ecological economy has been in the development stage from 2011 to 2020, judging from the keyword timeline map (Figure 5). The rapid development stage began in 2016, and keywords in many aspects, such as energy use, product, natural resource, productivity, etc., appeared. The emergence of these keywords indicates that the current ecological economy research mainly focuses on high quality development. Humans and nature are repaying the

![Figure 4. The cluster map of keyword emergence intensity in the research field of ecological economy from 2011 to 2020](image1)

![Figure 5. Timeline map of keywords in the research field of ecological economy from 2011 to 2020](image2)

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opportunity cost of economic development by accelerating the world’s environmental degradation. The best choice to control and reduce environmental degradation to achieve sustainable development is to explore renewable energy [19]. The concept of sustainable development was proposed in the 1980s. Since its emergence, the concept has achieved great success [20].

3.3 Analysis of Research Institutions

Based on the CiteSpace software, we obtained a cooperation map of institutions that published articles on ecological economics from 2011 to 2020. Each node in the graph represents an institution. The larger the node, the higher the institution’s citation count. Institutions that publish documents in this field include the Chinese Academy of Sciences, Nanjing University, and other institutions. The top ten institutions are the Chinese Academy of Sciences, Beijing Normal University, University of Chinese Academy of Sciences, Peking University, University of Queensland, Stockholm University, Univ Autonoma, Barcelona, Russian Acad Sci, Univ British Columbia and Tsinghua Univ. Among them, the most cited institution is the Chinese Academy of Sciences, with a citation count of 149, indicating that the research field of this institution is a research hotspot. Moreover, we found that compared with other countries, the literature published on “eco-economy” is mainly concentrated in related institutions in China, and the number of documents published by foreign institutions is relatively small. In addition, according to the network map of cooperative institutions in this field (Figure 6), there are 398 nodes, 343 connections, and a density of 0.0043, indicating that the cooperation between the various institutions in the field of ecological economics is not close enough. The cooperation between organizations needs to be strengthened, which is conducive to promoting the development of the ecological economy. The result analysis shows that the institution with the largest number of documents published in the field of “eco-economy” is the Chinese Acad Sci; comparing with foreign countries, relevant institutions in China have published more “eco-economy” documents, and the partnership is not close enough.

3.4 Analysis of Authors

By importing the data into CiteSpace software for analysis, a network map of authors’ cooperation in the field of the ecological economy was obtained (Figure 7). Our results shows that there are more authors published in the field of ecological economics, among which the author with the highest citation counts are YONG GENG, FRIDOLIN KRAUSMANN and WEI WANG, all with a citation count of 5, indicating that they are influential scholars in this field. The fourth author is YU ZHANG, with 4 citations. There are more scholars in ecological economics, but there are fewer teams with close collaboration between authors. The connections in the figure indicate the cooperation among scholars. The

![Network Map of Cooperation Between Institutions](https://doi.org/10.30564/re.v3i3.3685)

**Figure 6.** The network map of cooperation between institutions in the ecological economy research field from 2011 to 2020

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largest cooperative group is a 10-person team such as Fan qin, Yu Ma, Rui Zhang, Wei Liu, Yang Zhou, and Big Chen. We found that cooperation within the group and inter-group cooperation was less.

4. Conclusions and Prospect

Based on Web of Science (WoS) to retrieve English literature in the field of ecological economics, using bibliometric methods, CiteSpace software was used to analyze the research progress in ecological economics from 2011 to 2020, and analyze the research hotspots, institutions, authors, etc. in this field.

From a research perspective, researchers and related institutions play an essential role in ecological economy research. Judging from the number of documents issued, it has grown rapidly since 2011. Based on the analysis of the cooperation network of authors and institutions, the relationship between authors and institutions is inadequate, and cooperation density is poor. We found that China is the leader in ecological economics research, and related institutions in China have published many “ecological economy” documents. The Chinese Academic Science University is the leading research institution and biggest publisher of ecological economics documents. However, the closeness of cooperation between research institutions in the “eco-economy” is small, and the citation frequency of papers is relatively low, which has little effect on the promotion of research in ecological economics. The most productive authors in ecological economics are YONG GENG, FRIDOLIN KRAUSMANN and WEI WANG, etc. However, the paper has a low frequency of citations and little influence.

From the perspective of research hotspots, related articles on the ecological economy have diverse research perspectives, but they need to be expanded and deepened. Through keyword co-occurrence analysis, the top seven research hotspots in ecological economics include carbon dioxide emission, metabolic transition, hospitality model, forest carbon project, degrowth activist and circular economy indicating that the current research is mainly focused on sustainable development. From the perspective of overall changes in research hotspots, we found that the current research hotspots in ecological economics are sustainable development and high-quality development; the areas of concern are also more extensive. Paying close attention to the issue of carbon dioxide emissions and looking for a sustainable development model.

Based on Research Frontiers’ perspective, research on the ecological economy from 2011 to 2014 mainly focused on CO₂ emissions, energy use, political economy, and evaluation methods of ecological economics. The Frontier hot topics from 2015 to 2019 changed to plant, state, methodology, etc., after which more words emerged. The research is microscopic, and the objects are changed to financial development and metabolism, which appeared in 2019. These aspects are still researched, proving that
it has practical significance. In terms of burst intensity, ecological economics has the highest burst intensity, and valuation, common, industrial ecology, etc. ranks second. According to the research data, the burst all started in 2012.

Currently, the development of ecological economics is still the main concern of humankind. The environment is a frontier topic. Environmental sustainability has attracted much attention, and there are many sustainable development concepts in the economic field. This field is in a stage of rapid development. There is an upward trend in research fever among scholars in ecological economics, with increasing research results and a significant increase in the number of scientific research papers. From 2011 to 2020, 3074 articles were published. Combined with the visual analysis of research in the field of ecological economics, this article proposes the following research prospects:

(1) Strengthen exchanges and cooperation between institutions and scholars. In the context of society’s close attention to the development of ecological economics, researchers and institutions should strengthen research cooperation, continuously improving their scientific research quality and use the knowledge spillover effect to carry out cross-regional and interdisciplinary research cooperation.

(2) Strengthen research based on the value of ecological economics. The value of ecological economics depends on its development method, which depends on the function of each ecosystem, and the function of the ecosystem depends on the structure of the ecosystem. Therefore, to strengthen the study of ecological economic value, it is necessary to analyze the structure of the ecological system, explore its functions, and outline the composition of ecological economic value through the establishment of an index system. In-depth understanding of the impact of different ecosystems on the development of ecological economy, the function of the ecosystem and the construction of an index system of ecological economic value is needed.

(3) Ecosystems include farmland, forest, and grassland ecosystems. These ecosystems provide ecological services to humans. Various ecosystems are interconnected. They promote, and restrict each other. When a particular ecosystem is destroyed, it is difficult for other ecosystems to keep evolving. Therefore, further research requires a broader perspective, and an in-depth study of the interactions between various ecosystems is necessary.

Acknowledgement

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ARTICLE
Opportunities and Challenges of Rehabilitating Degraded Land in the Case of Cheha Woreda, Gurage Zone, SNNP Region, Ethiopia

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ABSTRACT
The research was conducted in chaha wereda gurage zone SNNP region of Ethiopia. The aim of the study was to assess opportunity and challenges of degraded land rehabilitation. From the total population of the study area 20% (73) respondents were selected in order to achieve the objective of the study at hand, for the study both primary and secondary data was generated. The primary data collection was started with a preliminary survey followed by a key informant interview, focus group discussion, and household survey with questionnaires. The secondary data were collected from books, unpublished thesis, project report, and workshops, open ended questionnaire and checklists for interview. The households were selected using stratified sampling technique (Cochran) sample size formula the process of analysis of the study was carried out using qualitative description and quantitative analysis. The collected data were analyzed using descriptive statistics, the quantitative data were analyzed frequency and percentage when appropriate the qualitative data were discussed to substantiate the study. And the results were expressed in the form of tables and graphs. The findings of the study indicated that limited labor availability, high cost of maintenance. Lack of knowledge, soil conditions, high surfaces runoff, poor vegetation coverage, poor monitoring and evaluation, poor implementation and poor training on the technology use are major challenges.

1. Introduction
1.1 Background of the Study
In Ethiopian, land degradation has become a serious problem affecting all spheres of social, economic and political life of the population. It is one of the major challenges to agricultural development and food security of the country. The rate of the country’s land degradation is very high. A large portion of the agricultural land, which is mainly located in the highland part of the country, is affected by severe to moderate land degradation. The world is now in a period of rapid, anthropogenic driven environmental changes occurring without historic patterns. These rapid environmental changes and degradations are brought about by land cover changes, fragmentation, invasive species, and pollution. The land use change in East Africa have transformed natural land cover to farm lands, grazing lands, human settlements and urban centers at the exposition of natural vegetation. These changes are associated with deforestation, biodiversity loss and agricultural intensification.

Land degradation includes all process that diminishes the capacity of land resources to perform essential functions and services in ecosystems. Principal processes of land
degradation include erosion by water and wind, chemical degradation (comprising acidification, salinization, fertility depletion, and decrease in cation retention capacity), physical degradation (comprising crusting, compaction, hard-setting, etc.) and biological degradation (reduction in total and biomass carbon, and decline in land biodiversity)\(^9\).

### 1.2 Statement of the Problem

In Ethiopia, the heavy dependency of people’s livelihoods on agricultural and in appropriate use of natural resource resulted in the fast and vast land degradation. On the other hand, development of agricultural sector partly depends on land productivity\(^2\). However the resource is seriously threatened by land degradation and aggravates the food insecurity problems in the country through its adverse impact on the crop yield. The country could not feed its population at present and it will have difficulties during in the near future partly due to serious land degradation. Therefore, improving productivity of land is so crucial in improving the agrarian population in particular and the overall economy of the country in genial without the proper management of land resource. It becomes a challenge for Ethiopia to feed the incising population. As a result, there should be appropriate land management systems to improve the productivity of land particularly in lowland areas where the problem of land degradation is severe. In an attempt to contribute in bridging the above stated gap, the study was focused on assessing challenges and opportunity of land rehabilitation practice.

### 1.3 Objective of the Study

The general objective of the study is to assess the opportunity and challenge of degraded land rehabilitation practice on the study area.

### 1.4 Research Question

Based on the above specific objectives, the research attempts to answer the following question:

- What are opportunities for degraded land rehabilitation in the study area?
- What are challenge and shortcomings in undertaking land rehabilitation practice?
- What are the main socio-economic, institutional and natural factors that affect the practice of land rehabilitation?

### 1.5 Significance of the Study

The study will generate information for different stakeholders, researchers, policy makers, governmental and nongovernmental organization, and farmer’s local level organizations to design develop effective land rehabilitation practices and strategies.

### 1.6 Scope of the Study

The research is geographically delimited to cheha wereda, gurage zone, SNNP region in 2019 G.C. The conceptual delimitation of the study is only focusing on assessing the opportunities and challenges of degraded land rehabilitation practices on study area alone.

### 2. Methodology

#### 2.1 Description of the Area

#### 2.1.1 Location

The survey was conducted in Cheha wereda, Gurage Zone SNNP, and Ethiopia. This area is located 171 km Southwest from Addis Ababa and 17 km from Wolkite town\(^7\).

#### 2.1.2 Topography and Vegetation

According to (Cheha woreda, Buchace kebele unpublished annual report 2020) the percent of topographic features constitute flat. 98% and up and down 2% that is suitable for farming practice and the vegetation type in the study area dominantly characterized by Eucalyptus, Mango, Bamboo, inset etc are dominantly characterized vegetation. The land has a dominantly level or flat topography that is suitable for farming.

#### 2.1.3 Soil Type

The study area was endowed with different soil colors. Black: it covers 30%; Brown: it covers 10% and Red: it covers 60% even though the dominant soils are red color and black color soils\(^7\). These types of soils are very useful for the production of different fruits and the dominant soil color is red color.

#### 2.1.4 Climate

The climate condition of the study area is kola. The annual rainfall is 1200 mm and altitude 13000-1565 the maximum temperature of the area is 30 °C degree centigrade and minimum temperature of 25 °C degree centigrade. The rainfall is high in summer season (June - August) and a little rainfall in the winter season\(^7\).

#### 2.1.5 Land Use and Farming System

The land use of the study area is both crop cultivation
and livestock rearing. The most important crop in the study area cereal crops includes Inset, teff and maize. Leguminous and vegetation are mainly grown in the study area. The dominantly cultivated annual crops are cereal crops such as maize, Teff, Inset and legumes are grown in the study area. The dominant livestock productions are donkey, ox, hen and cow. Those types of framing system the major source of income through which farmers work to enhance their living standard. Generally, the socio-economy of the society in the study area is dominated by agricultural production system. The land was covered different activities such as grazing land, land forest, water body, crop land and settlement.

2.2 Sources and Types of Data

2.2.1 Sources of Data

The source of data was by using both primary and secondary data sources. The primary data were collecting through structured and interviews, open ended questionnaires and filed observation. Because it is a vital way to obtain the relevant data for the community about the challenge and opportunity of land degradation, the secondary data were collected from different published and unpublished document, project reports and different government offices and internet service.

2.2.2 Types of data

The study was used both quantitative and qualitative data types.

Quantitative data

The data were collected from the wereda household and was converting into numerical form or it was obtained as numerical form from secondary sources.

2.3 Sampling Technique and Sampling Size

In the study purposive sampling techniques were used and the total population of study area is 10,000. The sample size of the study was determined statistically using the formula described by \([3]\) as:

\[
\text{Sample size, } n = N \times \frac{Z^2 \times p \times (1-p)}{e^2} \left[ N - 1 + \frac{Z^2 \times p \times (1-p)}{e^2} \right]
\]

Where

\( N \) = Population size

\( Z \) = Critical value of the normal distribution at the required confidential level

\( p \) = Sample proportion

\( e \) = Margin of error

\[
(10,000 \times (1.96^2) \times 0.5 \times (1-0.5))/((0.05^2)/(10000 - 1 + ((1.96^2) \times 0.5 \times (1-0.5))) = 10000*(3.8416)*(0.25)/0.0025/(9999+(3.8416)*0.5*(0.5)/0.025)) = 10000*0.9604/0.0025/(9999+0.9604/0.0025) =10000*384.16/9999+384.16 =10000*384.16/10383.16
\]

The value of sample size \( n \) = 369.9 Household

But limitation of time, budget and other constraint we cannot collect data from all households so assessing the study area use 20% of the 369*0.2=73.

2.4 Methods of Data Analysis

The data were analyzed and interpreted according to the nature of the data. Therefore, all required data were analyzed by using the descriptive data analysis method using the recent version of SPSS software to describe, summarize and present quantitative and qualitative data. The interpretation was presented in the form of tables, graphs, and percentages.

3. Results and Discussion

3.1 Demographic Characteristics of Household

In demographic parameter: age, sex educational status, material and family size status of respondent are discussed are base line for study since land rehabilitation practice are participatory program encompasses all parameter of the respondent is important to determine which have opportunities and challenge of land rehabilitation practice as Table 1, among the interviewed households' 72.6% were male headed household and remaining 27.4% were female headed household. This shows that the majority is males because of males have especial knowledge than females on the land. Below Table 1 shows that about 23.3% of 20-30 age, 28.8% of 31-40 age, 35.6% were 41-65 and 12.3% >65 age group. Then among them most of people are the age >65 were UN productive and were 41-65 more productive. Age classes of <15 and >65% are categorized as unproductive and 15-65 more productive age class. The productive age class is playing very important roles in any development activities including of land rehabilitation practices activities in the study area.

Marriage characteristic have an effect up on development initiatives as Table 1 about 27.4% single, 72.6% married. Household that has household head and children undertaking collective participatory actions on agricultural land. But those who have the single can undertake the action individually cannot easily complete the rehabilitation action in on farm lands. The educational
status is one of the factors on the community land rehabilitation practices. The community having large number educated individual easily accepts technology regarding rehabilitation practices and undertaking and implement it practically \[6\]. The below Table 1 shows that among total numbers of respondents that attends school currently and educated including who are able to write their name is almost 52% and remaining respondent almost 48% was illiterate. This shows that most of the respondents who cannot participate in the area land rehabilitation practices were illiterate.

Religion is one of the factors which affect rehabilitation practices in the case of study area context. There are different religious holidays that do not allow the labor work regarding respective religious. Majority of the people in the study area were dominantly Orthodox and Muslims they enforced to celebrate this holiday in the month. This may have a negative effect on the rehabilitation practices. The below Table 1 shows that among total number of respondents the dominant group almost 50.7% were Orthodox and 45.2% follows Muslim and the remaining 4.1% protestant.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Status</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex of respondent</td>
<td>Male</td>
<td>53</td>
<td>72.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>20</td>
<td>27.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
<tr>
<td>Age of respondent</td>
<td>20-30</td>
<td>17</td>
<td>23.3</td>
</tr>
<tr>
<td></td>
<td>31-40</td>
<td>21</td>
<td>28.8</td>
</tr>
<tr>
<td></td>
<td>41-65</td>
<td>26</td>
<td>35.6</td>
</tr>
<tr>
<td></td>
<td>&gt;65</td>
<td>9</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
<tr>
<td>Education of respondent</td>
<td>Illiterate</td>
<td>35</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Primary</td>
<td>16</td>
<td>21.9</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>7</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>Diploma and above</td>
<td>15</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
<tr>
<td>Religious of respondent</td>
<td>Orthodox</td>
<td>37</td>
<td>50.7</td>
</tr>
<tr>
<td></td>
<td>Muslim</td>
<td>33</td>
<td>45.2</td>
</tr>
<tr>
<td></td>
<td>Protestant</td>
<td>3</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
<tr>
<td>Material status of respondent</td>
<td>Married</td>
<td>53</td>
<td>72.6</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>20</td>
<td>27.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
</tbody>
</table>

![Respondents of occupation](source)

**Figure 1.** Occupation categories of respondents in the study area

Source: structure interview, (2020)
3.2 Form of Land Degradation in the Study Area

According to [8] findings, the study area was requested to rank which of the below forms of land degradation is common in their farm land (Table 2). As it was clear that soil fertility decline (54.8%) is the top of all forms and ranked as 1st followed by forest degradation (42.5%) and gully erosion (2.7%) as 2nd and 3rd rank perceptively. This shows that the dominant form of land degradation was soil fertility and decline and gully erosion was less concern form community point of view in the study area.

Table 2. Form of land degradation (n=73)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency</th>
<th>%</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gully erosion</td>
<td>2</td>
<td>2.7</td>
<td>3rd</td>
</tr>
<tr>
<td>Forest degradation</td>
<td>31</td>
<td>42.5</td>
<td>2nd</td>
</tr>
<tr>
<td>Soil fertility</td>
<td>40</td>
<td>54.8</td>
<td>1st</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Sources: structural interview HH,(2020)

3.3 Common Land Rehabilitation Practices

As Table 3 below shows that all individuals in the study area activity involved in land rehabilitation practice listed below. Accordingly starting from the most dominant land rehabilitation practice in the study area, around 24.7% of individual in the study area replied that that use of soil bund and to divert it in to appropriate water way in the dominant land rehabilitation practice in our area followed by use of SWC which constitutes around 45.2% and also beyond the forestation and reforestation which accounts 30.1% as means of land rehabilitation practice was common but least concern from community point of view.

Table 3. Land rehabilitation practice (n=73)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency</th>
<th>Parentage%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A forestation and reforestation</td>
<td>22</td>
<td>30.1</td>
</tr>
<tr>
<td>SWC</td>
<td>33</td>
<td>45.2</td>
</tr>
<tr>
<td>Soil bund</td>
<td>18</td>
<td>24.7</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Sources: structural interview HH,(2020)

3.4 Soil Fertility Management Practice in the Study Area

Farmers at individual level of practice different land management activities mainly to increase agricultural yield and to conserve the natural environment on their plot of land farmer apply chemical fertilizer to obtain high agricultural yield. Inorganic fertilizer application is the perquisite in the study area 19.2% as many part of the country experience due to loss of soil fertility which is caused by erosion according to survey results, manuring, crop rotation 20.5% and 27.4% respectively were one of the most important method of improving soil fertility as well as conserving soil on cultivated field. But only 32.9% of inter cropping the respondent in the study area. This shows that individual in the study area does not give attention to agro forestry practice.

Table 4. Soil fertility management practice (n=73)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical fertilizer</td>
<td>14</td>
<td>19.2</td>
</tr>
<tr>
<td>Manu ring</td>
<td>15</td>
<td>20.5</td>
</tr>
<tr>
<td>Crop rotation</td>
<td>20</td>
<td>27.4</td>
</tr>
<tr>
<td>Inter cropping</td>
<td>24</td>
<td>32.9</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Sources: structural interview HH, (2020)

3.5 Opportunity of Degraded Land Rehabilitation

3.5.1 Family Members Motive to Involve in Land Rehabilitation Practice

Regarding the involvement and support of household member to land rehabilitation practice in study area almost 68.5%of respondents of family members are willing to participate in any natural resource conservation activity.

Table 5. Willingness to participate land rehabilitation practice (n=73)

<table>
<thead>
<tr>
<th>Items</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>50</td>
<td>68.5</td>
</tr>
<tr>
<td>No</td>
<td>23</td>
<td>31.5</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Sources: structural interview HH,(2020)

3.5.2 Assistance/Cooperation of Neighborhoods for Land Rehabilitation Practice

Respondents were also asked to tell the assistance and cooperation of the neighboring people to land
rehabilitation practices. Accordingly, above the table of respondents in indicated that there is cooperation among the societies to rehabilitation degraded areas on their farm plot and community land respondents show that the majority of the people in their localities are willing to perform any resource management practice. A number of reasons were in dictates by the respondents as the way the assistance gained increase over time. The sampled household heads who indicated increase in assistance over time gave the reason: people give attention for long term benefits rather than working for short term benefits. Many people are trying to focus on their social gain rather than personal benefit increase in the level of awareness among some communities to minimize problems of land degradation in cooperated manner than performing at individual level. The increase in awareness among communities regarding the problem of land degradation. As a result, there are extensive efforts made by all stakeholders to conserve natural resources and to perform land restoration practice in the study area.

3.6 Challenge of Land Rehabilitation Practice in the Study Area

Socio-economic, institutional and environmental challenge of land rehabilitation practices in the study area

As shown in the Table 6 there were many challenges associated with land rehabilitation practice in the study area. Regarding socio-economic challenges about 31.5% respondent replied that lack of materials like stone to undertake land rehabilitation practice and also inorganic fertilizer in the major challenge followed by high cost maintenance 23.3% and lack of knowledge how to perform and maintain the structures 45.2% are the major socio-economic challenge from community point of view. The environmental challenges about 16.4% respondent poor vegetation like deforestation to undertake land rehabilitation practice climate condition 32.9% and remaining soil condition land rehabilitation practice. Accordingly, about 30.13% of individuals confirmed that lack of awareness of introduced the fundamental institutional factor that affects our land rehabilitation practices, poor Implementation design 26% and poor monitoring 16.4% and remaining 27.47% replied that poor training on technology use affects our land rehabilitation practices. As the result shows that lack of awareness is the major institutional challenge in the study area.

| Table 6. Socio-economic, institutional and environmental challenge (n=73) |
|--------------------------------------------------|--------|------|
| Socioeconomic challenge                        | Respondent | %    |
| Lack of knowledge                              | 23     | 31.5 |
| Lack of material                               | 33     | 45.2 |
| Cost maintenance                               | 17     | 23.3 |
| Total                                          | 73     | 100.0|
| Environmental challenge                        |        |      |
| Poor vegetation                                | 12     | 16.4 |
| Climate condition                              | 24     | 32.9 |
| Soil condition                                 | 37     | 50.7 |
| Total                                          | 73     | 100.0|
| Institutional challenge                        |        |      |
| Poor training on technology                    | 20     | 27.47|
| Poor implementation                            | 19     | 26   |
| Poor monitoring and evaluation                  | 12     | 16.4 |
| Lack of awareness                              | 22     | 30.13|
| Total                                          | 73     | 100.0|

Sources: structural interview of wereda demonstration office, (2020)

4. Conclusions and Recommendation

Based on the above results soil fertility decline, forest degradation, erosion, deforestation and limited use of conservation measures, poverty, lack of awareness and lack of martial are the major underline cause and soil fertility decline forest degradation are the major form of land degradation in the study area. As it was clearly indicated in the result and discussion part as the respondent indicated the major land rehabilitation practice undertaken by the farmers are some different SWC practices, a forestation and reforestation, crop rotation and intercropping. In the study area lack of awareness poor implementation design, and poor monitoring and evaluation of newly introduced land rehabilitation technology is considered as major institutional gap and affect effective use of technology from community point of view and the environmental challenge are soil condition, poor vegetation cover and climate conditions are the major environmental challenge respectively in the study area are the majority of family members are willing to participate in any natural resources conservation activities. The cooperation among the societies to rehabilitation degraded land areas on their farm plot and community land respondent show that majority of the people in their localities are willing to perform any resource management practices.

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References


DOI: https://doi.org/10.30564/re.v3i3.3668
Due to the excessive use of mineral resources, more greenhouse effect gases have been emitted into the atmosphere. The global warming effect induced by human activity has been intensified much more than ever before. Accordingly, ecology systems are being suffered significant changes over the world. Soil is one of our most important natural resources. Physically, soil is the crust surface of the earth that can supply nutrients and support for plant growth. It often determines the nature of the vegetation present and related animals in number and types. Soils provide habitats for a myriad of living organisms, from small mammals and reptiles to tiny insects to microscopic cells of unimaginable numbers and diversity. Moreover, soil plays an important role as an engineering medium in human-built ecosystems [1]. Therefore, the understanding of soil and its response to the global warming is important for the harmony of human and environment. Generally, soil has four major components as air, water, mineral matter, and organic matter. The relative proportions of these four components greatly influence the behavior and productivity of soils. Through interactions of energy flow and mass exchange, soil plays the role as the crucial interface medium for air, minerals, water and life, and forms a complex integrated body, ecosystem. To a great extent, soil ecology is one new branch of ecology that study the relationship between soil biota and environment, including ecological structure, function, balance and evolution of soil ecosystem. The application of soil ecology will be a benefit for the reasonable and sustainable use of land resources and be important for agriculture, forestry and grazing production.

Soil ecology is concerned with interactions between organisms or between organisms and the soil environment. Soil ecology has its origins in soil biology and soil zoology, the study of organisms in the soil habitat. Soil ecology and soil science are related, yet different disciplines, with soil science focusing more on physical processes, the classification and genesis of soils, soil chemistry, and soil physics. Recent efforts in soil ecology have focused on developing a mechanistic understanding of how organisms and soils interact to yield patterns of soil biodiversity, nutrient cycling function within ecosystems, and feedbacks to global change mechanisms [2]. Many achievements have been made last several decades. However, there are still many challenges faced in research. Most studies are independent case studies.
based on either short-term field surveys or laboratory incubations. As a result, the findings are not systematic and adequate for generalization. Accordingly, it is important to establish more controlled field facilities or experiments and conduct more cross-site collaborative experiments \[^3\]. Moreover, some critical scientific questions should be considered in the future research to face the challenges. Simultaneously, there is a great chance for researchers to contribute and push the study of this field ahead significantly. Research in Ecology, a peer-review and open access journal, provides a good service platform to publish these related study results. Certainly, all ecology-related topics could be accepted to publish on this journal.

**References**


